STEMI Performance in Six Hospitals within One Healthcare System

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Abstract

Background: How quickly percutaneous coronary intervention is performed in patients with a ST-elevation myocardial infarction (STEMI) is a core quality measure, reported as door-to-balloon (D2B) time in minutes. Aims: This retrospective study of 1193 patients was undertaken to explore how well six hospitals in a large healthcare system achieved time from the emergency department (ED) to the first ECG <10 minutes and D2B time [?]90 minutes. Methods: STEMI coordinators provided shelved data collected between 1-1-2016 and 8-31-2018. D2B times were available for 818 patients. The overall median time from the ED to the first ECG was 4 minutes and all hospitals achieved median times less than 10 minutes. There was a significant difference between the hospital with the highest (88%) and lower percentage of patients (79%) attaining the recommended time from the ED to the first ECG <10 minutes (p<0.025). The overall median D2B time for the entire sample was 63 minutes and the difference between D2B time among hospitals was significant (p<0.001). Collectively, the six hospitals achieved a D2B time <90 minutes well above the recommended goal by the American Heart Association (87.8% vs 75% respectively, p<0.001). The most compelling finding was that field STEMI activation with direct patient transportation to the cardiac catheterization laboratory(CCL) resulted in significantly shorter D2B times than ED activation (p<0.001). Patients with D2B time <90 minutes had a lower mortality than those with D2B time >90 minutes (5.3% vs 19.0% respectively, p<0.001). Conclusion: Achieving D2B time <90 minutes has a significant impact on mortality associated with STEMI. Field STEMI activation with direct patient transport to the CCL significantly shortened D2B time. Further study is needed to assess the benefit of close collaboration between hospital and Emergency Medical Service personnel to implement this mode of patient transportation to the CCL to improve STEMI care.

INTRODUCTION

Ischemic Heart Disease (IHD) continues to be the single most common cause of death worldwide. The estimated incidence of a myocardial infarction (MI) in the US remains high and is approximately 605,000 new attacks annually. MI and coronary heart disease were two of the ten most expensive conditions treated in 2013 with an estimated total healthcare cost of 218 billion dollars.[1] Mortality rates have declined in part due to timely percutaneous coronary interventions (PCI) for ST segment elevation myocardial infarction (STEMI) but the burden and risk factors remain significant.[2] Guidelines continue to evolve with increased emphasis on the rapidity of infarcted-related coronary artery recanalization.[3-5]Health care systems continue to strive for improvement in door-to-first ECG and door-to-balloon (D2B) times and the identification of system, provider, and patient barriers is paramount to improved patient outcomes.[3,4,6-8]

BACKGROUND

The management of STEMI has evolved over the past 30 years and the importance of timely reperfusion in STEMI by pharmacological or catheter-based measures has been well substantiated.[5.9,10] Reperfusion of an occluded coronary artery remains a significant contributor to positive patient outcomes.[4,5,8,11] D2B time is a recommended core quality measure for the Joint Commission on Accreditation of Health Care

Organizations and the Centers for Medicare and Medicaid Services.[12] Achieving an overall D2B time [?]90 minutes in Primary PCI centers is an important time target in acute STEMI care.[3,13] The recommended minimal adherence score to a D2B [?]90 minutes is 75% of STEMI patients in the US.[3,14]There is evidence that D2B times are improving over time. An analysis of all STEMI patients demonstrated that D2B times < 90 minutes increased from 44.2% to 91.4% over a period from December 31, 2005 to September 30, 2010.[15] Short D2B time is important because a delay in treatment for STEMI increases the likelihood and amount of cardiac muscle damage due to localized hypoxia.[5]

An ECG is the initial diagnostic indicator of STEMI.[4,5] Delay in obtaining an ECG adversely influences D2B time and has commanded extensive investigation in the past. An important time target in acute STEMI management is to obtain an ECG in [?]10 minutes from time of admission.[3-5,13] An integrated approach that includes chief-complaint-based ECG processes initiated by a triage nurse could improve the target rate of door-to-ECG time of < 10 minutes for potential STEMI patients.[16] Both target rate of door-to-ECG < 10 minutes and D2B times< 90 were significantly increased. The integrated ECG approach remained a significant predictor of door-to-ECG time [?]10 minutes beyond the contribution of other covariates.

Current guidelines strongly recommend that all patients with STEMI symptoms seek emergency medical services (EMS) and arrive at the hospital via ambulance.[10,17] EMS activation shortens the time to definitive treatment, facilitates obtaining an ECG early, allows for prompt activation of the STEMI team, and significantly improves D2B time.[17-19] Prior studies regarding mode of transportation indicate low EMS use by STEMI patients (10-53%), use of private transportation (16% self-driving) and suboptimal improvement in EMS use (14-20%) despite extensive community campaigns to educate the public.[19-22] Recent data demonstrated slightly better EMS use (60-62%) for STEMI patients directly presenting to PCI capable hospitals. [10,17] Wireless ECG transmission from the ambulance, and verification of probable STEMI from the ED physician or cardiologist prevents delays that occur in the ED.[23] Although CCL pre-activation is recognized as an important factor in treating STEMI patients, it was found to occur in only 41% of patients with STEMI. [24] Mumma and associates found that a prehospital ECG was associated with a 10-minute reduction in first medical contact to balloon time.[25]Patients who have symptoms of ischemic chest pain and who have pre-hospital ECG changes consistent with STEMI should optimally bypass the ED and be transported directly to the CCL.[26,27]

Confounders may significantly contribute to a delay in reperfusion. Patient-related confounders are primarily comorbidities or an unstable clinical presentation, including inconclusive ECG findings, family interference, patient refusal, unstable hemodynamics, cardiac arrest and procedural difficulties.[6,28] Non-patient-related confounders are generally system-related difficulties such as availability of the CCL, inadequate staff, holidays and after-hours procedures. Weather can impede EMS ability to transport patients to the hospital.[7,29]

AIMS AND OBJECTIVES

The primary aim of this retrospective study was to explore how well six regional hospitals within the same healthcare system achieved the recommendation for a D2B time [?] 90 minutes. Secondary aims were to describe how well the hospitals attained the recommendation to obtain the first ECG within 10 minutes of admission, and to attempt to identify modifiable barriers to adherence to STEMI performance recommendations.

SETTING

Databases from six hospitals within the same healthcare system were included in the study. The hospitals were all located within a 50-mile radius of one another. Five of the hospitals had level 1 STEMI status. Further, 5 of the 6 hospitals had EDs and CCLs on the same floor. The sixth hospital required the use of a shared elevator to transport STEMI patients from the ED to the CCL. Three of the six hospital (#3, 4 and 6) were located in the suburbs and the other three hospitals (#1, 2 and 5) were located in urban areas.

METHODS

Following approvals from the appropriate Institutional Review Boards, the STEMI coordinators at the six hospitals compiled de-identified shelved data that had been collected for potential STEMI patients admitted between January 1, 2016 and August 31, 2018. The data were given to investigators for analysis; random numbers were assigned to the six hospitals. The tool used by the STEMI coordinators included variables as shown in Table 1. Using data provided on the collection forms, the investigators determined which of the following scenarios was present for each patient based on the possible methods patients received management for STEMI:

- Scenario A: ED admission (either by EMS or as a walk-in), ECG performed in ED, STEMI activation by ED physician and transported to CCL.
- Scenario B: EMS personnel perform the ECG in the field (field ECG), send ECG electronically to ED physician for activation, EMS personnel transport the patient directly to CCL.
- Scenario C: EMS personnel perform the ECG in the field, ECG sent electronically to ED physician for activation, EMS personnel transport the patient to ED and patient transported to CCL by CCL personnel.

Data Analysis

Descriptive statistics were conducted for the sample overall and by hospital, with mean and standard deviation (SD) being reported for age and frequencies and percentages being reported for all other patient characteristics, which were categorical. Hospitals were compared via an ANOVA test for age and chi-square tests for all other variables when the sample size was sufficient. The primary outcome of D2B time, as well as secondary outcomes of time of ED arrival to first ECG, time from last ECG to activation, and time from activation to transport to the CCL was examined with medians and interquartile ranges (IQR) and compared across hospitals via Kruskal-Wallis tests. Percent of patients who met the guidelines of first ECG in < 10 minutes and of D2B time in < 90 minutes was calculated overall and by hospital and compared via chi-square tests. Also, a binominal test compared the overall percentage of patients with D2B times [?]90 minutes to the American Heart Association minimal adherence score of 75%.[3]

Predictors for D2B times were identified via multivariate linear regression. Each characteristic was analyzed in an unadjusted model predicting D2B time then included in one or both of two adjusted models. Both models contain age, gender, mode of arrival (walk-in versus not), scenario of arrival, day of the week, patient confounder (yes/no), and non-patient confounder (yes/no). One model then contained indicators for the individual hospitals while the other contained the number of steps from the ED to the CCL. All analysis was conducted in IBM SPSS at a significance level of 0.05.[30]

RESULTS

A total of 1193 patients were included in the STEMI database provided by the coordinators at the six hospitals. As shown in Table 2, the number of patients per hospital ranged from 122 to 322. As expected, males exceeded females in the overall sample (66.3% versus 33.5%, respectively). The mean age of patients in the database was 62.0 ± 13.7 years. Of the 1193 patients in the databases, D2B times were available for 818 patients. Reasons provided for incomplete D2B data of the other 375 patients included missing data (37.3%), cardiopulmonary arrest/death before reaching CCL (16.5%), normal coronary arteries (13.6%), catheterization canceled by ED physician or cardiologist (13.3%), non-STEMI (6.4%), atypical presentation/STEMI missed (5.1%), radiology imaging for an alternative diagnosis (3.2%), patient refusal (2.1%), inability to cross lesion (1.1%), needing coronary artery bypass graft (1.1%) and unavailable CCL (0.3%).

There were significant differences in the patient populations in the six hospitals (Table 3). For example, mean patient age differed significantly among the six facilities ($p=0.009$). While 68.2% of the total patients were admitted via ambulance, this form of admission was highest in hospital #1 and lowest in hospital #6. Similarly, scenarios for admission differed significantly among the hospitals ($p<0.001$). Overall, Scenario A was the most frequent type of admission (54.8%), followed by Scenario C (39.5%). Although Scenario B occurred infrequently overall (4.9%), its highest frequency was observed at hospital #5 (18.5%).

At least one patient-related confounder variable was present in 23.4% of the total sample (Table 3) and was distributed differently among the six hospitals (p<0.001). Patients at hospital #3 had the highest incidence of at least one patient-related confounder (34.4%), while hospital #4 had the lowest incidence (10.6%). Four patient-related confounders were found to differ significantly among the six hospitals including cardiac arrest (p=0.015), intubation (p=0.009), need for MRI or CT (p=0.017) and inconclusive ECG findings (p=0.05). At least one non-patient-related confounder was present in 4.4% of the population and differed significantly among the facilities (p<0.001). There was not enough data to examine the specific non-patient related confounders by hospitals. The mortality rate of patients in the database was 9.2% and there was significant difference in the mortality across all six hospitals (p<0.001). The highest mortality was observed in hospitals #1 (13.9%) and #2 (15.5%) and the lowest mortality was in hospital #5 (2.8%).

As shown in Table 4, the median (IQR) overall time from the ED to the first ECG was 4 (1-8) minutes. All hospitals had median times less than 10 minutes; however, 25% of the patients in hospitals #2, #3 and #5 had median times above 9 minutes. The range in median values among the six hospitals differed significantly (-7.5 to 5 minutes, p<0.001). When categorized as [?]10 minutes or >10 minutes, hospital #4 met the requirement of [?]10 minutes 88% of the time, while hospital #2 only met it 79% of the time, p=0.025. The overall median (IQR) ECG to activation time was 3 (-9 to 9) minutes and the shortest one was -5 (-16 to 4) minutes (hospital #4). Although there is no guideline recommendation for ECG to activation time, studies suggest activation should occur within 5 minutes after the diagnostic ECG is obtained. Since D2B time is a time sensitive medical situation, the time to activation is an important factor that contributes to overall D2B time. The overall median (IQR) time of activation to the CCL table in this study was 40 (31-48) minutes.

As shown in Table 5, the overall median (IQR) D2B time for the entire sample was 63 (50-78) minutes. The difference between D2B time among hospitals was significant (p<0.001); the majority of the hospitals had a median D2B time of 60-62 minutes and the worst median D2B time was 72 (58-87) minutes at hospital #5. When D2B times were categorized as [?]90 or >90 minutes the highest percent of adherence to the guideline of [?]90 minutes was 97.1% at hospital #4 and lowest was 79.1% at hospital #5, p<0.001. The overall percent of adherence was higher than the minimal adherence score recommended by the American Heart Association (87.8% vs 75% respectively, p <0.001).[3]

The two hospitals with the highest mortality (hospitals #1 and #2) had longer average D2B times (72.1+ 51.5 minutes for hospital #1 and 73.0+ .6 minutes for hospital #2) than in the total patients documented (69.2+ 38.9 minutes). These findings indicate that more patients in hospitals #1 and #2 did not get recanalization of the occluded vessel as timely as others. The effect of D2B times< 90 minutes on mortality was very substantial; patients with D2B times < 90 minutes had a significantly lower mortality than those with D2B times >90 minutes (5.3% vs 19.0% respectively, p<0.001). The effect of D2B times on mortality was not completely consistent and there were some unexplainable findings. Hospital #5 had the highest average D2B time (80.3+ 45.7 minutes) and lowest percentage of attaining D2B times< 90 minutes (79.1%) but had the lowest mortality rate (2.8%). Hospital #6 which had a lower mortality rate (7.8%), had a slightly lower percentage of patient achieving D2B times< 90 minutes (86.8%) but had substantially lower average D2B times (66.4+ 44.1 minutes) than the total population.

As shown in Table 6, significant predictors of D2B time included: hospital, number of steps from ED to CCL, mode of arrival, scenario of arrival, and patient-related confounders: Significant differences in D2B time were found in some of the hospitals, even after adjusting for other variables. When compared with hospital #1, hospital #3 had a 14.4-minute lower D2B time (p=0.01) and hospital #6 had a 11.6-minute lower D2B time (p=0.01) after adjusting for other variables. Although hospital #4 had a substantially lower unadjusted time (p=0.049), it was not statistically significant (p=0.08) after adjustment. Hospitals #2 and 5 also did not differ significantly from hospital #1 in D2B time. While the unadjusted number of steps from the ED to the CCL was statistically significant (p=0.02), the difference was no longer statistically significant (p=0.31) after adjusting for other variables.

Compared to 'walk-in' as a mode of arrival, EMS arrival was associated with a 12.5-minute shorter D2B time, p<0.001; however, after adjusting for other variables it was no longer significant. After adjusting for other variables, compared to Scenario A, Scenario B was associated with a 27.3-minute lower D2B time (p<0.001) and Scenario C was associated with a 22-minute lower DTB time (p=0.001). Field ECG/activation with or without stopping in the ED was superior to ED ECG/activation (either walking in or EMS transport). Presence of one or more patient-related confounders was associated with about a 21.5-minute greater D2B time in both adjusted models compared to someone with no patient-related confounders ($p<0.001$ for both). Presence of a non-patient-related confounder was found to have a 9 to 10-minute greater D2B time in both adjusted models; however, it was not a significant predictor of D2B time in either model (model 1: p=0.13 and model 2: p=0.17). Non-significant predictors of D2B in the unadjusted and either adjusted models were age and day of week.

DISCUSSION

Because all six hospitals included in the study were closely located geographically and were managed within the same healthcare system, it was surprising to find significant differences among them in the frequency of variables that could increase D2B time. Identified in the study were differences in age, ambulance versus walk-in, scenario of admission, and patient-related variables (cardiac arrest, need for intubation, need for radiologic evaluation, and inconclusive ECGs). However, none of these variables were consistently different between the higher and lower performing hospitals. It is possible that differing socioeconomic variables (such as poverty and level of education) affected outcomes among the six hospitals.

The American Heart Association has recommended that at least 75% of STEMI patients receive the first ECG < 10 minutes of admission.[3] Collectively, the percent of adherence to this recommendation among the six hospitals was 83.1% (median 4 minutes, IQR 1-8). The six hospitals included in this study collectively performed above the minimal adherence score for a D2B time [?]90 minutes (87.8% adherence as opposed to 75%, respectively).[3]Nonetheless, there was considerable variation among the six hospitals; the two highest performing hospital complied in 94.9% and 97.1% of the cases, while the lowest performing hospital complied in 79.1% of the cases. It is difficult to explain why this wide range of compliance occurred; as there was no consistent pattern in the distribution of suspect variables among the six sites.

An expected finding was that patients with D2B times >90 minutes had a significantly higher mortality than those with D2B times< 90 minutes. However, the data on mortality is not conclusive because the study lacked information describing whether the mortality was cardiac or non-cardiac related as well as there was no documentation on comorbidity or underlying cardiac disease such as left-ventricular function, valvular heart disease, prior congestive heart failure, prior stent or coronary artery bypass graft.

Perhaps the most important finding of our study was the effect of the scenario of admission to the CCL. Scenarios B and C were associated with significantly better D2B times than was Scenario A. This is reasonable, given that these scenarios involve EMS admission with ECGs performed in the field. Scenario B is best in that it bypassed an ED admission and patients are transported directly to the CCL. An expected finding was that the presence of confounders significantly affected D2B time. While there were insufficient data to assess the significance of non-patient related confounders on D2B time, the presence of at least one patient-related confounder greatly increased D2B time.

LIMITATIONS

As with any retrospective database analysis, it was not possible to have input into variables included in the tool nor to ensure accuracy of data recording. Among variables not reported in the database were socioeconomic status (such as income category, educational level, and insurance status) and a measure of co-morbidities. All of these variables could have conceivably affected D2B times of patients in the database. Although over 1000 patients were included in the database, only 818 had D2B times; further, the number of patients in the six hospitals differed greatly (varying from 122 to 322). Given the large number of variables, it is possible that the study was under-powered to detect important differences among the hospitals.

IMPLICATION FOR PRACTICE

Results of this study corroborate those of other investigators in regard to reducing D2B time by achieving STEMI activation in the field as opposed to in the ED. Further, our recommendation to collaborate with

EMS personnel to accomplish these outcomes is supported by findings from a study reported by a group of physicians and nurses in South Carolina.[31] These investigators were able to significantly lower D2B times by empowering EMS providers to activate the CCL prior to reaching the hospital. By so doing, there were able to reduce their baseline D2B time from 52.5 minutes in 2011 to sustained D2B times under 40 minutes over the next four consecutive years.

Results from this study also emphasize the need for STEMI coordinators to diligently promote precise documentation of STEMI logs to identify potential problem areas in the implementation of STEMI guidelines. They need to look for non-patient-related barriers that may impact D2B times in their respective clinical sites and explore options for removing these barriers to promote timely care of these patients. Documentation of socioeconomic status on STEMI logs would be helpful in clarifying how this variable may contribute to treatment delays.

CONCLUSIONS

Overall, the six hospitals included in the study exceeded the minimal adherence score of 75% for patients having an ECG in< 10 minutes of admission (83.1%) as well as having a D2B times [?]90 minutes (87.8% of the cases). Nonetheless, it is noteworthy that only two hospitals achieved greater than 90% adherence to a D2B time [?]90 minutes. The two greatest contributors to D2B time identified in the study were patient-related confounders and scenario of admission. While the patient-related confounders cannot be controlled, close collaboration between hospital and EMS personnel is recommended to explore strategies to increase field activations and direct patient transportation to the CCL.

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